5. Construction Requirements

Because all first-generation LMDS service providers will purchase their licenses in an FCC auction and because there will be significant competition with other services and video delivery systems in the market, Texas Instruments believes the Commission need not adopt construction requirements. LMDS licensees will have no incentive to "warehouse" spectrum because they will have made an up-front investment and, further, they would not be successful in foreclosing competition because of the other providers already in the market.

Further, an aggressive "build-out" timetable could hinder LMDS implementation and reduce license auction values. General interest in the service could diminish since bidders would have to save money for very near-term equipment purchases. Equipment availability concerns can be expected to cause additional bidding conservatism.

As a manufacturer of LMDS equipment, Texas Instruments might seem like a beneficiary of build-out requirements; purchasers would have to buy soon and, with limited equipment availability, prices could inflate. However, Texas Instruments and their customers are best served by the successful measured implementation of LMDS service. Texas Instruments believes that LMDS equipment may not be immediately available in large quantities and thus Texas Instruments suggests that the Commission refrain from adoption of a build-out requirement.

If, in spite of this, a construction requirement is deemed necessary, we recommend that the build-out period be as generous as possible and certainly more moderate than that suggested in the First NPRM. Accordingly, we believe that the proposed five year/one-third and ten year/two-thirds construction requirements are a step in the right direction, but could be moderated even further or discarded entirely without harmful effect.

6. Technical Rules

Texas Instruments believes that only limited technical regulations may be needed to ensure adequate interference control. Coordination between geographically adjacent LMDS systems and between LMDS systems, (hubs and CPEs) and MSS feeder link systems, (earth stations and satellites), should be required where they share the same frequency spectrum. Limited technical regulations may be needed to ensure adequate interference control and coordination of services. Parameters that could be a major factor in coordination are as follows:

- Equivalent Isotropically Radiated Power, EIRP,
- Channelization/Frequency,
- Modulation Type and Bandwidth,
- Frequency Stability,
- Receiver Parameters, (Noise Figure, Bandwidth and Thresholds).
- Antenna, (Gain, Beamwidth, Sidelobe Levels, Polarization, Cross Polarization), and
- System Geometry.

The value of these parameters will be different for the various systems, LMDS and MSS feeder links and have different affects on their operation. Thus, recommended guidelines might be appropriate, but technical rules for systems not yet developed or deployed may not accomplish the intended purpose to control or prevent interference. Thus, Texas Instruments recommends that applicants be required to coordinate frequencies with other licensees and applicants whose facilities are likely to be impacted by new proposals. The basis of coordination should be along the lines of 47 C.F.R. § 21.100 (d).

Texas Instruments supports the requirement for applicants to coordinate frequencies among themselves where applicants and licensees cooperate fully and make reasonable efforts to resolve technical problems and conflicts that may inhibit the most effective and efficient use of the spectrum. The following are specific replies to the request for comment in the Third NPRM.

1. Frequency Coordination

a. Maximum Power Flux Density

Power control in an LMDS system is one means of achieving optimum link parameters and a high performance, quality wireless delivery system in a variable environment. Attenuation due to rain or terrain variations may cause system power level fluctuations. The current requirements of 47 C.F.R. § 21.107 are acceptable guidelines where the power (EIRP) permitted to be used is stated as the minimum required for satisfactory technical operation commensurate with the size of the area to be served and the local conditions which affect transmission and reception. The maximum transmitter power allowed is 10 watts with a maximum allowable EIRP of 55 dBW. The maximum, per channel output power for the Texas Instruments hub transmitter is 1 watt (0 dBW) with an antenna gain maximum of 15 dB. The resultant EIRP density for the hubs are -61 dBW/Hz (with maximum rain attenuation) and -73 dBW/Hz for clear air. The CPEs have 100 milliwatt maximum transmitter power and 34 dB antenna gain. CPEs located 5 km from a hub would have a maximum EIRP density of -40 dBW/Hz, (20 dBW/MHz), during time of rain attenuation and -47 dBW/Hz (13 dBW/MHz) for clear air. Power control of the CPEs is utilized to maintain a constant signal level at the hubs for each of the CPEs. Thus, close-in CPEs (0.1 km) will have an EIRP density of -81 dBW/Hz for clear air.

Due to operational and system design variations Texas Instruments believes that a maximum power flux density at the coordination boundary need not be specified but, believes it is reasonable to require power control in order for the transmitting stations to maintain minimum EIRP for satisfactory technical operation commensurate with the size of the area served and the local conditions which affect transmission.

b. Orthogonally-Polarized Signals

Antenna polarization as shown in Appendix B is not the most significant factor in assuring that interference does not occur, but it can contribute to coordination if opposite polarization were used to discriminate between desired and undesired signals that are received at a particular location. If orthogonal-polarized signals (vertical and horizontal) were not made a technical standard, this interference mitigation would not be available for coordination. Thus, Texas Instruments supports restricting LMDS signal polarization to vertical and horizontal at the border region, (and within a 20 km of the BTA boundaries), if necessary to facilitate coordination between BTAs.

2. Equivalent Isotropically Radiated Power, EIRP

a. LMDS Hubs

The Texas Instrument LMDS hubs have a maximum transmitter power of 1 watt (0 dBW) per channel and an antenna gain maximum of 15 dB, yielding an EIRP of 15 dBW. In clear air, the maximum EIRP is set in the range of 3 to 5 dBW via the system power control.

b. CPE

The Texas Instruments CPEs have a maximum transmitter power of 100 milliwatts and 34 dB antenna gain resulting in a maximum EIRP of 24 dBW. Power control, to compensate for rain attenuation and range, is used to maintain a constant CPE return link signal level at the hub and accordingly the power is reduced for clear air operation and for those CPEs which are closer than 5 km to the hubs. The EIRP for CPEs located 5 km from the hub is 17 dBW for clear air and can be as low as -19 dBW for CPEs that are located close to the hubs.

c. Power Density

If the LMDS output power limits were to be expressed in terms of EIRP density we would recommend that a limit of 23 dBW/MHz maximum (similar to that in the proposed rule, Appendix B § 21.1018) be adopted. Further, it is recommended that employment of adaptive power control be implicated to accommodate coordination and to counter attenuation due to rain or terrain variations.

3. Spectral Efficiency

The Texas Instruments hubs use a DS3 digital modulation standard (45 Mbps) and a 40 MHz bandwidth for each channel. The CPEs make use of a 3.3 Mbps burst digital modulation return link and uses a 2.5 MHz bandwidth. Thus the hub average spectral efficiency is 1.125 bps/Hz and the CPEs spectral efficiency is 1.32 bps/Hz. Other systems that might use 27 Mbps and a 20 to 25 MHz bandwidth for each channel would also meet the 1.0 Mbps/Hz requirement. Therefore, a spectral efficiency standard for digital modulation of 1.0 bps/Hz is acceptable.

V. AUCTION RULES

Texas Instruments agrees that the use of competitive bidding to award LMDS and satellite licenses will promote the objectives of the Communications Act, Section 309(j)(3), which are to promote the -

development and rapid deployment of new technologies,

economic opportunity and competition,

recovery of the public spectrum value, and

efficient and intensive use of the spectrum.

If there is only one application for a particular license, we agree that the filing of a long-form application should proceed without delay. Also, it is reasonable that additional entities be allowed to file during a new filing period for GSO/FSS service and NGSO/FSS systems. Simultaneous multiple round bidding to award LMDS licenses appears to be the most appropriate for LMDS BTA licenses due to the interdependence of the licenses. Combinatorial bidding maybe appropriate for LMDS licensing where aggregations may offer business deployment efficiencies. If the FSS spectrum used for MSS feeder links in the 29.1 GHz to 29.25 GHz spectrum can not be co-shared with LMDS systems, hubs and CPEs, then it is recommended that this spectrum should also be included for competitive bidding.

VI. CONCLUSION

Texas Instruments supports the early resolution of the remaining issues in this proceeding so as to promote the early introduction of LMDS. Texas Instruments believes that both LMDS and MSS feeder links can share the 29.1 - 29.25 GHz spectrum allocation and must do so if LMDS is to reach its potential of providing digital, interactive video, data and voice services to American homes, businesses and schools. Moreover, Texas Instruments urges the Commission to avoid the imposition of unnecessary regulatory structures and to allow the maximum regulatory flexibility to LMDS equipment manufacturers and providers to design and implement a variety of LMDS applications.

Respectfully Submitted,

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August 28, 1995

APPENDIX A

APPENDIX A LMDS AND MSS FEEDER LINK CO-SHARING ANALYSIS

During the Negotiated Rule Making Committee a number of analyses were completed that indicated that co-sharing of the 28 GHz spectrum is possible. Report NRMC 46, Rev. A, (LMDS AND FSS-MSS Systems Interference and Co-share Techniques in the 28 GHz Band, Texas Instruments, September 5, 1994 (Revision A September 13, 1994) is provided as part one of this appendix for reference. This analysis covered both hubs and CPEs transmitting on the different satellite system receive frequencies. Analysis was also provided for the case where the FSS-MSS feeder link systems transmit on the LMDS system receive frequency. The CPEs transmitting on the Iridium receive frequency, (i.e.; 29.1 GHz - 29.2 GHz band) for a digital system provided 7.7 dB positive margin for the Iridium satellite receiver.

The margin reported in the NRMC 46 report is conservative since the average clear air CPE EIRP has been reduced to -50 dBW/Hz, (-47 dBW -3 dB), from the -42.8 dBW/Hz level used in the original analysis, a 7.2 dB improvement. This would result in a positive margin of 14.9 dB but there has been other factors recently identified by Motorola that would reduce these gains. Motorola has pointed out that their satellite antenna foot print is 9 to 10 times larger than the 200 km by 400 km area of § 21.1021 in Appendix B of the Third NPRM. The analysis of in NRMC 46 used 200 km by 1400 KM which is a factor of 2.85 times smaller than that recently suggested by Motorola. This larger area would reduce the C/I margin to 10.4 dB. Also, Motorola has indicated that the Iridium receiver bandwidth is now 6.25 MHz instead of the 4.352 MHz previously used in the

NRMP 46 analysis. This further reduces the margin gain by 1.55 dB to a margin of 8.85 dB. Thus, this shows that LMDS CPEs are able to make use of the 29.1 GHz to 29.2 GHz band with out causing harmful interference to the Iridium satellite receiver.

Additional concern has been expressed by Motorola on direct in beam coupling from the LMDS CPEs if they were transmitting in the 29.1 GHz to 29.2 GHz band. Part two of this appendix addresses this aspect where as the analysis in part one is the more general case which includes both main beam and sidelobe aggregrations.

The analysis of Mutual Interference of LMDS hubs along BTA boundaries is provided in Appendix B. This analysis shows that the radiation direction of the hub antenna (at the BTA boundary) and hub EIRP, at distances greater than 5 km from the BTA boundary, are the primary means of reducing cross BTA interference. Antenna polarization is shown to not be a major mitigation factor.

Appendix A
Part 1

NRMC 46 Rev A

LMDS AND FSS-MSS SYSTEMS INTERFERENCE AND CO-SHARE TECHNIQUES IN THE 28 GHZ BAND

TEXAS INSTRUMENTS

SEPTEMBER 5, 1994

(Revision A September 13,1994)

This document represents analysis and conclusions for the Texas Instruments LMDS systems and should not be extended to be representative of other systems such as Suite 12 which does not require mitigation controls as described in this document for coexistence with FSS-MSS satellite receivers.

INTRODUCTION

The following presents interference analyses from the LMDS systems configured by Texas Instruments into FSS-MSS satellites, and FSS-MSS ground terminals into the LMDS systems, (Hubs and CPEs). Mitigation of interference from the LMDS system into the FSS and MSS satellites is shown to be accomplished with a modification of the Texas Instruments LMDS hub design. Interference from FSS-MSS ground terminals is shown to be accommodated by applying known mitigation techniques at time of system deployment. Thus, with the approaches shown the LMDS and FSS-MSS systems can co-exist in the 27.5 to 29.5 GHz band.

ANALYSIS

Interference of LMDS into Teledesic Satellite Receivers

• Parameters:

• Teledesic feeder uplink

Xmtr power per carrier		-19.0 dBW
Occupied BW for each carrier	(0.225MHz)	-53.5 dB
Xmtr peak antenna gain		+36.0 dBi
Feeder uplink e.i.r.p. density (nominal)		-36.5 dBW/Hz

• C/I tolerance level

Required C/(No+I)	4.5 dB
Assumed I/No	-13.0 dB
Calculated C/I	17.6 dB

The Texas Instruments LMDS system for analysis consist of four different Hub types;

System #1	Wideband Digital
System #2	Narrowband Digital
System #3	FM, 17MHz
System #4	AM, MHz

The Texas Instruments LMDS CPEs use digital QPSK return links.

- TI LMDS system transmit e.i.r.p.'s

Hub e.i.r.p. density (Sys 1 & 2)	(+15dB ant)	-62.8 dBW/Hz
Hub e.i.r.p. density (Sys 3)	(+15dB ant)	-57.6 dBW/Hz
Hub e.i.r.p. density (Sys 4)	(+15dB ant)	-52.8 dBW/Hz
CEP e.i.r.p. density (Sys 1,2,3)	(+35dB ant)	-42.8 dBW/Hz
CEP e.i.r.p. density (Sys 4)	(+35dB ant)	-52.8 dBW/Hz

Peaking allowance (Sys 1,2,4 and CPE)	+2.0 dB
Peaking allowance (Sys 3)	+6.0 dB

- Scenarios and Assumptions
  - Modified FCC model used to examine interference scenarios
  - Areas of heavy and sparse Hub densities:
    Dense Hub spacing within Satellite Antenna footprint to provide mechanism for worst case analysis of interference
  - Sat. elevation angles **of 40 degrees** [examined] for worst case interference
  - Atmospheric attenuation included in path loss calculations
  - Antenna pattern masks used in antenna coupling geometries
  - [Control deployment % of TI systems to limit interference]
  - At most one CPE from any Hub transmits in any given frequency channel at a time
  - CPE antenna coupling is limited to pencil beam interaction
  - CPE antenna lookup angles restricted to 10 degrees or less and/or CPE power restricted for CPEs close to Hub.

• Results

-Interference includes signal peaking effects.

• Hubs: Each system C/I assumes 100% deployment of system.

Scenario	Sat. elev. angle (deg)	Hub density* in 52km x 53km Sy 1,2,3	Sy4	C/I WB dig Sys1	NB dig Sys 2	(dB) FM Sys3	AM Sys4
Run 1	40.0	100	236	29.9	29.9	20.7	16.2
Run 2		**112**	**560**	**29.2**	**29.2**	**20.0**	**12.2**

* This density applies to the Satellite antenna footprint. Outside this footprint the expected CONUS Hub density applies.

• CPEs

• Expected worst case time average:

Scenario	Sat. elev angle(deg)	Hub density in 53km x 53km	C/I (dB) Sys 1,2,3	Sys 4
Run 1	40.0	100 or 236	27.0	33.3
Run 2		**112 560**	**18.1**	**21.1**

• Worst Case Single CPE - System 1, 2 or 3 CPE antenna pointed directly at the satellite antenna:

Satellite feeder uplink at **40** deg elevation		
e.i.r.p. density (includes APC)	(+C)	-36.5dBW/Hz
CPE with **40** degree lookup *	(-I)	+42.8dBW/Hz
Polarization coupling		+3.0dB
Signal Peaking		-2.0dB
C/I		7.3dB

***Note: This effect is for a mispointed CPE antenna.**

Conclusions: LMDS interference into FSS Satellites

• TI LMDS Hubs into Teledesic

• Sys 1, 2, and 3. - No interference degradation from LMDS Hubs.

• Sys 4 - Worst case scenario shows **5.4 dB** desensitization.

• TI LMDS CPEs into Teledesic

• Sys 1, 2, and 3. - 10.3 dB interference problem with a **incorrectly pointed and** directly pointed CPE antenna. No interference problem for expected time average aggregate from CPEs.

• Sys 4 - 0.3 dB interference problem with single **incorrectly pointed and** directly coupled CPE. No interference problem for expected time average aggregate from CPEs.

Properly aligned CPEs and power control there is no interference into Teledesic satellite receivers. The TI CPEs will not transmit if not properly aligned.

Interference of LMDS into Iridium Satellite Receivers

• Parameters:

• Iridium feeder uplink

Xmtr power per carrier	(minimum)	-22.3 dBW
Occupied BW for each carrier	(4.375MHz)	-66.4 dB
Xmtr peak antenna gain		+56.3 dBi

Feeder uplink e.i.r.p. density (nominal) -30.4 dBW/Hz

Adaptive power control (range and atmosphere)

Sat elevation angle (deg)	APC level	effective e.i.r.p.
5.0	+12.4	-20.0 dBW/Hz
7.5	+11.3	-21.1 dBW/Hz
10.0	+10.3	-22.1 dBW/Hz
15.0	+8.6	-23.8 dBW/Hz
20.0	+7.3	-25.1 dBW/Hz

C/I tolerance level 20.9 dB

• TI LMDS system transmit e.i.r.p.'s

Hub e.i.r.p. density (Sys 1 & 2)	(+15dB ant)	-62.8 dBW/Hz
Hub e.i.r.p. density (Sys 3)	(+15dB ant)	-57.6 dBW/Hz
Hub e.i.r.p. density (Sys 4)	(+15dB ant)	-52.8 dBW/Hz
CEP e.i.r.p. density (Sys 1,2,3)	(+35dB ant)	-42.8 dBW/Hz
CEP e.i.r.p. density (Sys 4)	(+35dB ant)	-52.8 dBW/Hz

Peaking allowance (Sys 1,2,4 and CPE)	+2.0 dB
Peaking allowance (Sys 3)	+6.0 dB

• Scenarios and Assumptions

• Modified FCC model used to examine interference scenarios
• Areas of heavy and sparse Hub densities:
Dense Hub spacing within Sat. Ant. footprint to provide mechanism for worst case analysis of interference
• Satellite elevation angles examined for worst case interference
• Atmospheric attenuation included in path loss calculations
• Antenna pattern masks used in antenna coupling geometries

Scenarios and Assumptions (Continued)

- At most one CPE from any Hub transmits in any given frequency channel at a time
- CPE antenna coupling is limited to pencil beam interaction
- CPE antenna lookup angles restricted to 10 degrees or less and/or CPE power restricted for CPEs close to Hub.

- Results: Interference includes signal peaking effects.
  - Hubs: Each system C/I assumes 100% deployment of system.

Scenario	Sat. elev. angle (deg)	Hub density*in 200km x 1400km Sy 1,2,3,	Sys4	C/I (db) WB dig Sys1	NB dig Sys2	FM Sys3	AM Sys4
Run 1	5.0	890	2100	24.1	24.1	14.9	10.4
Run 2	7.5	890	2100	24.0	24.0	14.8	10.3
Run 3	10.0	890	2100	24.4	24.4	15.2	10.7
Run 4	15.0	890	2100	31.7	31.7	22.5	18.1
Run 5	20.0	890	2100	34.9	34.9	25.7	21.3

* This density applies to the Satellite antenna footprint. Outside this footprint the expected CONUS Hub density applies.

- CPEs
  - Expected worst case time average:

Scenario	Sat. elev angle(deg)	Hub density in 200km x 1400km	C/I (dB) Sys 1,2,3	Sys 4
Run 1	7.5	890 or 2100	28.6	34.9
Run 2			**20.4**	**26.7**

- Worst Case Single CPE - System 1, 2 or 3 CPE antenna pointed directly at the satellite antenna. **Randomized CPE antenna angles with CPE power controlled by range to hub.**

Satellite feeder uplink at 10 deg elevation

e.i.r.p. density (includes APC)	(+C)	-22.1dBW/Hz
CPE with 10 degree lookup	(-I)	+42.8dBW/Hz
Polarization coupling		+3.0dB
Signal Peaking		-2.0dB
C/I		21.7dB

- Conclusions: LMDS interference into MSS Satellites.
  - TI LMDS Hubs into Iridium

Sys 1 & 2 - No interference degradation results from the Hubs.
Sys 3 - Worst case scenario shows 6.1 dB desensitization.
Sys 4 - Worst case scenario shows 10.6 dB desensitization.

• TI LMDS CPEs into Iridium

No interference degradation is produced by the CPEs into the Iridium satellites **with the CPEs properly aligned. If a CPE is misaligned and transmitting then the worse case scenario (main beams directly coupled) will produce 0.5dB interference.**

If four CPEs within the satellite main beam should transmit in the same time slot (probability=2x10-6) the interference would occur at a 20 second interval and satellite burst error correction would correct for that problem.

Interference of FSS-MSS Ground Terminals into LMDS

The following provides a summary of the interference into LMDS Hubs and CPEs from the Teledesic and Iridium ground terminals with a separation distance of 1km.

CPE MAIN ANTENNA LOBE; Digital System:

Parameter	Iridium	Teledesic (TST-rain)	Teledesic (TGT-rain)
CPE Eb reqed. (dBW/Hz)	-184.0	-184.0	-184.0
CPE Eb/Io reqed. (dBW/Hz)	20	20	20
CPE reqed. Eb/(No+Io),(dB)	11.4	11.4	11.4
CPE Eb/(No+Io) (dB)	-57.7	-36.9	-15.4
CPE Margin Eb/(No+Io), (dB)	-69.1	-48.3	-26.8
CPE Margin Eb/Io, (dB)	-77.7	-56.9	-35.4

CPE ANTENNA SIDELOBE; Digital System:

Parameter	Iridium	Teledesic (TST-rain)	Teledesic (TGT-rain)
CPE Eb reqed. (dBW/Hz)	-184.0	-184.0	-184.0
CPE Eb/Io reqed. (dBW/Hz)	20	20	20
CPE reqed. Eb/(No+Io),(dB)	11.4	11.4	11.4
CPE Eb/(No+Io) (dB)	-27.7	-7.0	10.0
CPE Margin Eb/(No+Io),(dB)	-39.1	-18.4	-1.3
CPE Margin Eb/Io, (dB)	-47.7	-26.9	-5.4

CPE ANTENNA MAINLOBE; FM System

Parameter	Iridium	Teledesic(TST-rain)	Teledesic(TGT-rain)
CPE Eb reqed. (dBW/Hz)	-178.0	-178.0	-178.0
CPE Eb/Io reqed. (dBW/Hz)	20	20	20
CPE reqed. Eb/(No+Io),(dB)	15.9	15.9	15.9
CPE Eb/(No+Io) (dB)	-51.7	-30.9	-9.4
CPE Margin Eb/(No+Io),(d B)	-67.6	-46.8	-25.3
CPE Margin Eb/Io, (dB)	-71.7	-50.9	-29.4

CPE ANTENNA BACKLOBE; FM System:

Parameter	Iridium	Teledesic(TST-rain)	Teledesic(TGT-rain)
CPE Eb reqed. (dBW/Hz)	-178.0	-178.0	-178.0
CPE Eb/Io reqed. (dBW/Hz)	20	20	20
CPE reqed. Eb/(No+Io),(dB)	15.9	15.9	15.9
CPE Eb/(No+Io) (dB)	-21.7	-1.0	16.1
CPE Margin Eb/(No+Io),(d B)	-37.6	-16.9	0.2
CPE Margin Eb/Io, (dB)	-41.7	-20.9	0.6

HUB; Digital System:

Parameter	Iridium	Teledesic(TST-rain)	Teledesic(TGT-rain)
HUB Eb reqed. (dBW/Hz)	-184.0	-184.0	-184.0
HUB Eb/Io reqed. (dBW/Hz)	20	20	20
HUB reqed. Eb/(No+Io),(dB)	11.4	11.4	11.4
HUB Eb/(No+Io) (dB)	-35.4	-17.0	3.9
HUB Margin Eb/(No+Io),(d B)	-46.7	-28.3	-7.5
HUB Margin Eb/Io, (dB)	-55.4	-36.9	-15.4

ANALYSIS SUMMARY

Satellites/Hubs

The analysis of the LMDS hubs and the Teledesic satellites shows positive C/I margins for the digital and FM hubs and 1.4dB negative C/I margin (interference) for the AM hub systems. Analysis of the LMDS hubs and the Iridium satellites which operate with low elevation angles (5 degrees) have positive C/I margin (3.2dB) for the digital hubs, 6dB negative C/I margin with the FM hub systems and 10.5dB negative C/I margin with the AM hub systems. The C/I margins are positive (1.6dB FM and 0.4 dB AM) at a 15 degree elevation angle for the FM hub system and a 20 degree elevation angle for the AM hub system.

Satellites/CPEs

The analysis of the LMDS CPEs and the FSS-MSS satellites (Teledesic and Iridium) indicates that the CPEs with the expected worse case time average produced a positive C/I margin that ranged from 7.7dB to 19.7dB. Thus, with a properly deployed system of CPEs there is no mitigation required to coexist with the FSS-MSS satellites. A CPE pointed directly at a satellite would produce a negative margin (-10.3dB digital and FM and -0.3dB AM) for the Teledesic satellite within its beam.

Ground Terminals/Hubs-CPEs

The analysis of the LMDS system and the FSS-MSS ground terminals for Teledesic and Iridium indicates that the hubs and CPEs will experience significant interference if within the direct line of sight of each other. The negative margins at 1km distance range in the neighborhood of -55dB to -78dB for the Iridium ground terminals, and -20dB to-56db margins for the Teledesic TSTs and 0dB to -35dB for the Teledesic TGTs. It should be noted that if the distance between the Iridium ground terminals were to increase from 1km to 10km an improvement of 20dB would result which places their interference in the same range of the Teledesic TSTs. However, with the deployment scenarios associated with the Teledesic terminals they could be 100 meters (or closer) from an LMDS hub or CPE receiver. This would produce negative margins similar to those resulting from the Iridium ground terminals at 1km.

MITIGATION OPTIONS

The LMDS CPEs produce positive C/I margins for the FSS-MSS satellites and do not require any mitigation techniques other than proper system installation. The LMDS FM and AM hubs systems do produce negative C/I margins for the low elevation Iridium satellites and could require hub mitigation. Texas Instruments has recognized this possibility and have included quadrant 12dB adaptive power control in the TI hub design. This change allows positive C/I satellite margins for the Texas Instruments LMDS system and coexistence with the FSS-MSS satellites.

There are an number of options that are available that would mitigate the interference produced by the FSS-MSS ground terminals into the LMDS system. These include techniques for the Iridium ground terminals of operating at higher elevation angles, reduced power made possible due to the higher elevation angles and increased distances. The Iridium and Teledesic systems could also make use of blockage produced by earth berms, structures, buildings and trees. A summary of the benefits that could be gained using these techniques follow.

Mitigation Option	Interference Reduction	Minimum	Maximum
Increase 5 degree elevation angle;			
10 degree	7dB	7dB	
15 degree	11dB		
20 degree	15dB		15dB
Reduce maximum terminal power	3 to 6dB	3dB	6dB
Increase separation distance; 2km	6dB	6dB	
10km	20dB		20dB
Blockage			
berms,	40dB	40dB	40dB
structures,	10 to 40dB	10dB	40dB
trees	15 to 40dB	15dB	40dB
Reduced cell radius; 20%/4km radius	10dB	10dB	10dB
TOTAL		91dB	171dB

CONCLUSIONS

The analysis and mitigation techniques presented shows that the LMDS and FSS-MSS systems can coexist in the 27.5 to 29.5 GHz band with rules that control the LMDS and FSS-MSS power densities and standards that promotes proper system installation with appropriate mitigation techniques.

LMDS systems can coexist with the Teledesic system by making use of blockage and with the Iridium system by increasing separation distance (10km), blockage and reduced cell radius when near the Iridium ground terminals. The rules and standards are available to the NRMC and FCC to promote the full use of the 27.5 to 29.5GHz spectrum.

APPENDIX

The following appendix provides the details for the interference analysis between the FSS-MSS ground terminal and the Texas Instruments LMDS system and the interference analysis between the TI LMDS hubs/CPEs and the FSS-MSS satellites.

Ground Terminal to CPE Interference, CPE mainlobe, digital
Ground Terminal to CPE Interference, CPE sidelobe, digital
Ground Terminal to CPE Interference, CPE mainlobe, FM
Ground Terminal to CPE Interference, CPE backlobe, FM
Ground Terminal to HUB Interference
Analysis of TI LMDS CPEs into Teledesic Satellite Receivers
Analysis of TI LMDS HUBS into Teledesic Satellite Receivers
Analysis of TI LMDS CPEs into Iridium Satellite Receivers
Analysis of TI LMDS HUBS into Iridium Satellite Receivers

Analysis of TI LMDS CPEs into Iridium SV Receivers

09/01/95

Introduction and Assumptions:

One scenario run examines the impact of interference from TI LMDS CPEs into Iridium satellite receivers. In this run the parameters of both systems and the geometric arrangements select conditions to produce worst case interference from CPEs and into the satellite receiver. The analysis is performed with a modified version of the program developed and provided by the FCC for LMDS Hub into SV receiver interference. For any Hub, at most one CPE may transmit of a given frequency at a time. Thus, the FCC model is easily used to comprehend aggregate CPE interference in the same way as aggregate Hub interference, with a few minor modifications detailed below. The scenario run examines the expected level of interference in the SV receiver's of the Iridium system by the TI LMDS CPEs. This expected level of interference includes the directional coupling of CPE antennas in both azimuth and elevation. However, the worst case interference level occurs when direct coupling of the CPE and SV antennas occurs. This case is examined separately.

Several modifications to the FCC program more accurately depict the expected TI CPE into Iridium SV situation. (1) Alteration of the antenna patterns match antenna gain and pattern sidelobe structures to plots of the respective TI CPE transmit and Iridium receive antennas. (2) Inclusion of atmospheric attenuation of the signals according to analysis results supplied by Motorola as per CCIR Report 719-3. These attenuation levels correspond to Rain-Climatic Zone 3-5 as per the Motorola Excel Spreadsheet. (3) High density and low density areas of Hubs are supported by inclusion of Hub spacing parameters for the two respective areas. The high area is directed to be within the footprint of the satellite antennas to comprehend the worst case geometric situation. Sidelobe area assumes the low density Hub spacing and adjusts sample point interference power contribution accordingly. (4) The antenna depression angle of Hub antennas is altered to an antenna look up angle from CPE to Hub. Additionally, to simulate the differing angles of the CPEs to the Hub, an equally likely distribution of look angles for the CPEs with respect to the SV antennas is used for both azimuth and elevation. In elevation the distribution is restricted so the upward looking angle of the CPE antenna is restricted to at most 10 degrees. For CPEs close enough to a Hub that the angle would be more than 10 degrees, it is assumed that power control is employed for that CPE, so that its contribution to aggregate sidelobes does not exceed that of a full power CPE from 10 degrees.

Model outputs remain the aggregate C/I level and the C/I level contributions as a function of elevation angle to the satellite and as a function of satellite antenna off-axis angle. An additional output C/I level records the contribution within the satellite antenna footprint. The required C/I level into the Iridium system SV receiver assumes 20.9 dB for minimal interference. The model does not include peaking effects in the interfering signals. The peaking allowance depends on the interfering signal. The CPE signal for all 4 TI systems is the same, a digital signal. For this signal the peaking allowance is 2 dB.

Table 1 details the calculation of the E.I.R.P.s for the scenario run. The SV Feeder Uplink E.I.R.P. assumes use of adaptive power control by the SV feeder uplink to account for range and atmospheric losses. The E.I.R.P for feeder uplink in the separately considered direct antenna coupling is included also.

Table 1 - System Parameters

SV Satellite Interference Tolerance		
I/No Allowed (5% per service)	-13.0 dB	
C/(No+I) Required	+7.7 dB	
C/I Tolerance (Calculated)	+20.9 dB	
SV Feeder Uplink		
Xmtr. Power per Carrier	-22.3 dBW (min power)	
Occupied BW/Carrier 4.375 MHz	-66.4 dB	
Xmtr. Peak Antenna Gain	+56.3 dBi	
SV uplink e.i.r.p. density	-32.4 dBW/Hz (nominal)	

Adaptive Power Control: Includes range and atmosphere

SV Elevation Angle (deg)	APC level	Adjusted E.I.R.P.
7.5	+11.3 dB	-21.1 dBW/Hz
10.0	+10.3 dB	-22.1 dBW/Hz

Individual CPE Transmitter	Sys 1,2,3	Sys 4
Xmtr. Power Density	-77.8 dBW/Hz	-87.8 dBW/Hz
Xmtr. Peak Antenna Gain	+35.0 dB	+35.0 dB
CPE e.i.r.p. density	-42.8 dBW/Hz	-52.8 dBW/Hz

Results:

Output from the simulation run is attached. The result for expected worst case CPE interference with signal peaking included is summarized in Table 2. The interference level produced in the expected aggregate worst case situation indicate that desensitization of the SV receiver by the CPEs is not a problem.

Table 2 - Results

Scenario	SV El Angle (degrees)	Hub Spacing* (km) dense/sparse	C/I (dB) Sys 1,2,3	C/I (dB) Sys 4
Run 1	7.5	17 / 68	28.6	34.9

*The dense spacing applies to the satellite antenna footprint, while outside the footprint the spacing is adjusted to produce a total Hub density that agrees with the expected CONUS Hub density. The C/I's given for system 4 are adjusted to include 3.7 dB increase due to denser spacing for sys 4.

Table 3 records the worst case direct antenna coupling case. A system 1, 2 or 3, CPE is assumed to be co-location with the SV feeder uplink and to have the worst case lookup angle of 10 degrees so that direct coupling with the SV antenna occurs. The Azimuth look angle of the CPE is also assumed to be directly toward the SV. The C/I computation includes the antenna gains of the SV feeder and the CPE in the C and I entries as given (from Table 1). Since the are co-location no path loss difference term is needed. The only adjustments to the raw signal powers are for antenna polarization and signal peaking of the interfering signal. The C/I value obtained indicates that direct coupling of one CPE with the SV does not present an interference problem. The expected coupling from aggregate CPEs above indicates that direct coupling of even one CPE is unlikely. Direct coupling of two CPEs would produce a C/I of 18.7 dB, and would exceed the interference tolerance level by 2.2 dB, but this situation is extremely unlikely.

Table 3

SV feeder uplink at 10 degree elevation (includes APC for range and atmosphere)	-22.1 dBW/Hz	(C)
CPE directly coupled with 10 degree lookup	+42.8 dBW/Hz	(-I)
Polarization coupling	+3.0 dB	
Signal Peaking	-2.0 dB	
C/I	21.7 dB	

Appendix A
Part 2

LMDS Subscriber Terminal, (CPE)
and
FSS-MSS Receiver
Co-share Analysis for 29.1-29.25 GHz

This analysis details the parameters associated with the Texas Instruments LMDS subscriber terminals and Motorola Iridium satellite receivers for use in an analysis of sharing of the 29.1 to 29.25 GHz frequency. These parameters support the analysis which shows that the LMDS subscriber terminals, including those where the satellite is within the 2.5 degree main beam, are able to operate without harmful interference to the satellite receiver. This analysis treats the total area within the satellite footprint and the aggregate of the CPEs which have the satellites within their 2.5 degree beam width. During the NRMC of 1994 analysis showed that the aggregate of CPEs with both digital and FM modulation did not result in harmful interference. The current analysis recognizes reduced CPE power, (20 milliwatts versus 1 watt clear air) and the return link duty factor, (4 percent versus 100 percent).

LMDS/CPE Parameters

1.	Number of unique subscriber channels	48
2.	Maximum number of subscribers per Node,(48 channels)	4608
3.	Subscriber distribution	uniform
4.	Subscriber duty cycle	4%
5.	Antennas with elevation of <5 degrees	90%
6.	Antenna gain	34dB
7.	Antenna 3 dB beamwidth, degrees	2.5
8.	CPE Tx power control range	50dB
9.	CPE Tx bandwidth, MHz	2.5
10.	CPE Tx power maximum, clear air	-17dBW
11.	Hub density, 200km X 400 km,25% density	250

Satellite parameters

1.	Coverage area	200 km X 400 km
	a. Coverage area increase	2000 km X 400 km
2.	Allowed power spectral density[1]	-26dBW/MHz-km ^{2}
3.	Receiver bandwidth	6.25 MHz

[1] CC Docket No. 92-297, Third Notice of Proposed Rulemaking, July 28, 1995; Appendix B, 21.1010, Table 1, Climate Zone 3,4,5